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REPORT

COMPUTER PROGRAM: MF sky-wave interference

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THE BRITISH BROADCASTING CORPORATION July 1973 (RA-109)

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COMPUTER PROGRAM: MF SKY-WAVE INTERFERENCE

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Summary

A short self-contained computer program for calculating sky-wave interference at m.f. has been written. The program employs a simple empirical law for calculating field-strength and makes a correction for the transmitting aerial vertical radiation pattern, the take-off angle being derived from the great circle distance and the number of 'hops'. Protected field-strengths are calculated for each wanted service area from the interference levels from individual co-channel and adjacent-channel sources, from all co-channel transmitters taken together, from all adjacent-channel transmitters taken together and from all co- and adjacent-channel transmitters taken together.

Issued under the authority of

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1. Introduction

This report describes a short program to compute m.f. sky-wave interference which has been designed as an aid in the preparation of international plans for m.f. broadcasting. Because it uses recognised prediction methods and is very economical to run, it could provide a ready means for testing a number of possible plans or be used to assist in the assessment of ad hoc modifications to these plans. For the calculations the transmitter information is read in from cards, permitting maximum flexibility in setting up new plans. The cards hold details of all the known transmitters to be considered from which any selection may be made to run the program. If required, the frequency of any station may be changed and various options are available which are explained in Section 3.

The purpose of the program is to assess the effect of co-channel and adjacent-channel interference by sky-wave propagation in service areas centered on any number of specified transmitters. (These are called the wanted transmitters). The program selects those transmitters which are co-channel and adjacent-channel with each wanted transmitter in turn and computes protected field-strengths based on the sky-wave interference from these interfering sources, separately and in combination. The combined effect of interfering sources is derived by taking a weighted sum of the interfering signal powers, the weighting being in accordance with protection ratios which are determined by the frequency spacing between the wanted and interfering carriers.

A distinction is made between interfering stations which are on precisely the same frequency as the wanted signal as to whether they will be carrying the same or different programme material. This affects the choice of the protection ratio.

2. The input cards

The transmitter input cards contain the following information:–

(i) Frequency (a whole number of kHz)
(ii) Station number (numbered in frequency sets)
(iii) Station name
(iv) Country
(v) Latitude and longitude
(vi) Transmitter power (in dB rel. 1 kW)
(vii) Programme code (this enables the program to distinguish between stations carrying the same or different programme material).

A set of change cards can be added to the transmitter cards to indicate frequency changes to selected stations. These additional cards also permit options on the selection of wanted and interfering transmitters by the program. The options are described in the next section.

3. Options

There are six options for running the program; five of these require that the option variable is set to the appropriate value on the change cards. If no change cards are included in the input the program will run in its basic form in which each station from the input set is treated as wanted in turn, co-channel and adjacent-channel stations are then selected from the remainder and treated as interfering sources.

3.1. 'Cards'

When the option variable is set to 'CARDS' the total set of transmitters considered is restricted to those appearing in the change cards. Otherwise the program runs as above (frequency changes may, of course, be to the same frequency if no alteration is required).

3.2. 'Single'

In this case only those stations listed by the change cards are considered as wanted; all stations which are input on existing sets or change cards are used as potential sources of interference.

3.3. 'Europe', 'Africa' or 'Asia'

If the option variable is set to either of these continents wanted transmitters are only taken from the continent indicated.

4. Vertical radiation pattern (VRP)

Three types of vertical mast-radiator aerials are provided for. These are 'short', 'λ/4' and 'λ/2' respectively. The v.r.p. corrections applied for these types follow the recognised EBU method[1] and are shown in Fig. 1. The correction to be used is chosen in accordance with the specified transmitter power.

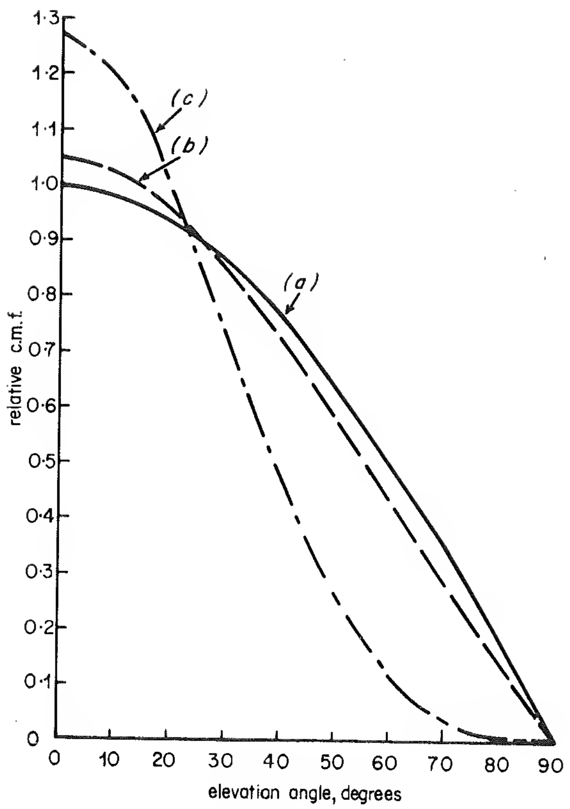


Fig. 1 - Vertical radiation patterns for transmitting aerials normalised to c.m.f. = 300 Volts
(*a*) Short aerial (*b*) $\lambda/4$ aerial (*c*) $\lambda/2$ aerial

Type 1, 'short', transmitter power $\leqslant$1 kW
Type 2, '$\lambda/4$', transmitter power $>$1 kW, $<$50 kW
Type 3, '$\lambda/2$', transmitter power $\geqslant$50 kW

This procedure has been adopted as the actual aerial types are not known in the majority of cases. In practice aerial heights tend to increase with transmitter power roughly in this way. These curves are normalised to a c.m.f. of 300 Volts which is nominally that of a 1 kW transmitter and a short aerial (100% efficient) in the horizontal direction. The appropriate correction is applied by assuming that the reflection point in the ionosphere is 100 km above the surface of the earth and calculating the take-off angle also taking into account the minimum number of 'hops' which are involved. The minimum number of 'hops' for each path is determined from the great circle distance. The radiation patterns are assumed to be identical on all bearings.

The v.r.p.'s take no account of the reduction of field strength at very small angles of elevation due to poor ground conductivity close to the aerial. This fact may introduce error in a small percentage of the field strength calculations but will not be serious for planning estimates.

5. The median field-strength

The median field-strength (dB rel. 1μV/m) predicted for each transmitter in the wanted service area is calculated from a simple experimental* formula which is a function of the great circle distance only. This formula is known to be reasonably accurate for distances greater than 3000 km. Referring to Fig. 2 it is seen that it also corresponds closely to the CCIR[2] curve for distances less than 2500 km taken at a frequency of 1000 kHz. The frequency dependence of the CCIR estimate is weak and it appears that the proposed curve is very adequate at all distances for planning purposes.

A flow diagram for the field-strength sub-routine is given in Appendix III.

6. Interference weighting

The program specification requires that the protected field-strength in the service area should be calculated in view of each interfering transmitter taken individually and in view of all co-channel transmitters taken together and all adjacent-channel transmitters taken together. The combined effect of many interference sources is achieved by weighted signal power addition, the weighting curve of Fig. 3[3] being used for the purpose.† As specified, frequency spacings of up to 4 kHz cover co-channel sources; spacings from 5–10 kHz cover adjacent-channel sources. A separate curve based on frequency spacings can be employed when it is necessary to distinguish between transmitters carrying the same or different programme material. In the present case the 'same programme' situation only

* Contained in an interim document of the EBU which is not yet published.

† The protection ratios are being reconsidered and may be modified in the future.

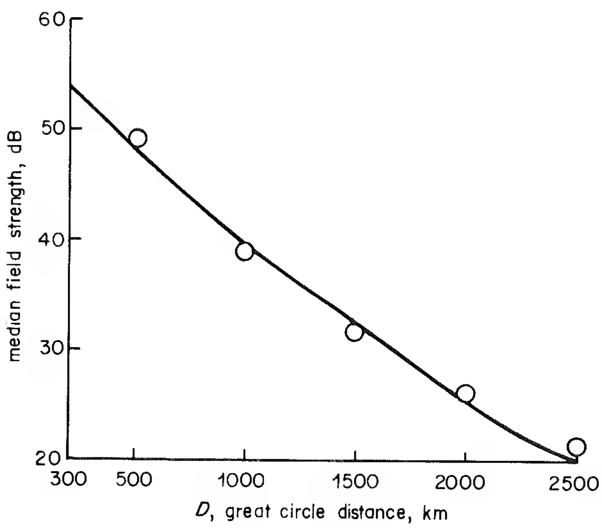


Fig. 2 - Median field-strength with great circle distance for c.m.f. = 300 Volts, λ = 300 m

(1) Full line = $80{\cdot}2 - 10 \log_{10} D - 0{\cdot}00777\ \lambda^{-0{\cdot}26}\ D$ dB, CCIR curve

(2) Circles $= \dfrac{396}{4 + 0{\cdot}001D} - 40$ dB
empirical law used in the program

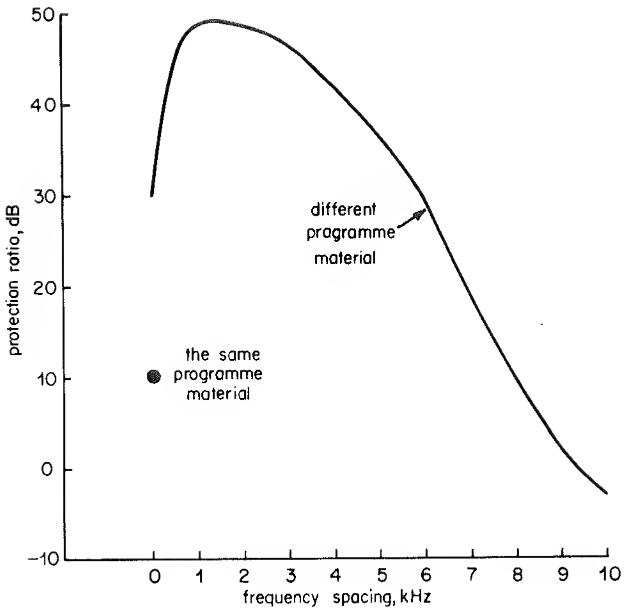


Fig. 3 - Weighting curve (protection ratios) with frequency difference

applies when the interfering source has zero frequency spacing. The weighting curve is included in the program as a data statement. No interpolation is required as only integral values of the argument are allowed.

7. Output

An example of line printer output is given in Appendix II. The output data includes, amongst other information:

(1) the name of the transmitter serving the wanted area; its frequency and code number:

(2) a list of all interfering transmitters which are either co-channel or adjacent-channel, their existing and newly assigned frequencies, the protected field-strength required in view of each one taken alone and the appropriate protection ratios:

(3) the protected field-strength required in view of all the co-channel interfering signals taken together:

(4) the protected field-strength required in view of all the adjacent-channel interfering signals taken together:

(5) the protected field-strength required in view of all the co-channel and adjacent-channel interfering signals taken together.

At the end of each run the number of equal protected fields for multiple co-channel, adjacent-channel and the combined cases are totalled in dB steps.

8. Discussion

The computer program described in the foregoing is intended as a tool for m.f. service planning on an international basis. More sophisticated programs are being considered for the future and these would be expected to contain extensive data banks of, for example, ground conductivity, magnetic dip angles, etc. It should be remembered, however, that computer data banks can be costly to store and handle in a program and the probability that the cost and complexity will be justified in terms of improvements in prediction will have to be carefully assessed. The short self-contained program described can easily be adapted for use on most computers and, therefore, it might be arranged to be available at international meetings as an on-the-spot aid to negotiations. The only subroutines required are those for standard mathematical functions.

9. References

1. Ionospheric propagation on long and medium waves, EBU Document TECH. 3081-E, March, 1962.
2. Sky-wave propagation curves between 300 km and 3500 km at frequencies between 150 kHz and 1600 kHz in the European broadcasting area. CCIR Report 264-1, XI Plenary Assembly, Oslo 1966, Vol. II, p. 297.
3. CCIR Recommendation 449/1, XIIth Plenary Assembly, New Delhi, 1970, Vol. V, Part I, p. 25.

SMW/AMM

Appendix I

INPUT DATA (Cards)

A – EXISTING STATIONS

Variable Name	Format	
NTXS	I4	Total number of transmitters in existing set
KHZCOD	I6	Frequency and station number
NAMCUN	4A6	Name and country
ALAT	I4 I3 A1	Latitude in degrees and minutes (N or S)
ALONG	I4 I3 A1	Longitude in degrees and minutes (E or W)
POWDB	I3	Transmitter power in dBs
ISYNC	I3	Programme code

B – CHANGE CARDS

NFRE	I4	New frequency
NUMNEW	I2	No. of transmitters to be allocated this new frequency
IWAREA	A6	Option variable (See Section 3)
OLDFCD	I6	Frequency and number of station in existing situation, to be changed to NFRE (NUMNEW cards)

Appendix II

An example of line printer output

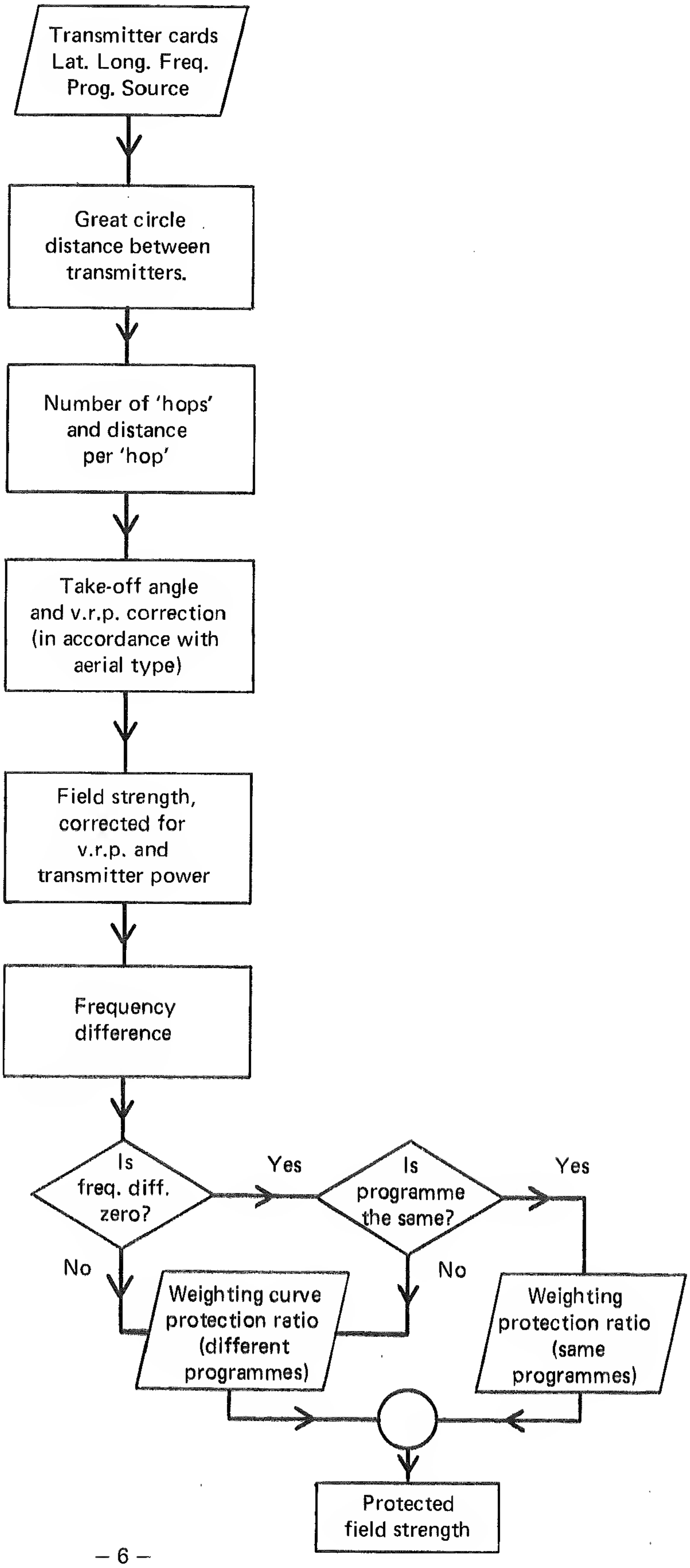
M.F.CALCULATION FOR RECEIVER DROITWICH G 121405 1214 0

NAME		EXISTING FREQ(KHZ)	NEW FREQ(KHZ)	DIST KM	POWER DB	PROT. RATIO	PFS DB	NAME		EXISTING FREQ(KHZ)	NEW FREQ(KHZ)	DIST KM	POWER DB	PROT. RATIO	PFS DB
BORDEAUX	F	120501	1205 1	826	20	2	65.3	AKKO	IRS	120502	1205 2	3659	10	2	24.1
KRAKOW	POL	120503	1205 3	1546	18	2	53.4	RZESZOW	POL	120504	1205 4	1720	18	2	51.3
SUBOTICA	YUG	120505	1205 5	1714	4	2	35.7	WASHFORD	G	121401	1214 1	150	18	10	65.6
BROOKMANS PARK	G	121402	1214 2	144	17	10	63.8	MOORSIDE EDGE	G	121403	1214 3	150	17	10	64.6
WESTERGLEN	G	121404	1214 4	425	16	10	74.0	BURGHEAD	G	121406	1214 6	608	13	10	68.4
LISNAGARVEY	G	121407	1214 7	360	10	10	68.6	TALLINN	URS	121408	1214 8	1837	23	30	82.9
TIRANA	ALB	121409	1214 9	2050	30	30	87.5	STARA ZAGORA	BUL	122301	1223 1	2341	15	2	39.7
MADRID	E	122302	1223 2	1335	17	2	55.1	RIMINI	I	122303	1223 3	1412	8	2	43.5
FALUN	S	122304	1223 4	1407	20	2	57.2								

MULTIPLE PFS(DB REL. 1 MUV/M) CO-CHANNEL 89.1 ADJACENT CHANNEL 66.6 CO- & ADJ. CHANNEL 89.1

Appendix III

Subroutine MFCALC



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